The Future of Energy at Wesleyan: Carbon Neutrality & Energy Infrastructure Modernization

WESLEYAN UNIVERSITY PHYSICAL PLANT

Wesleyan University

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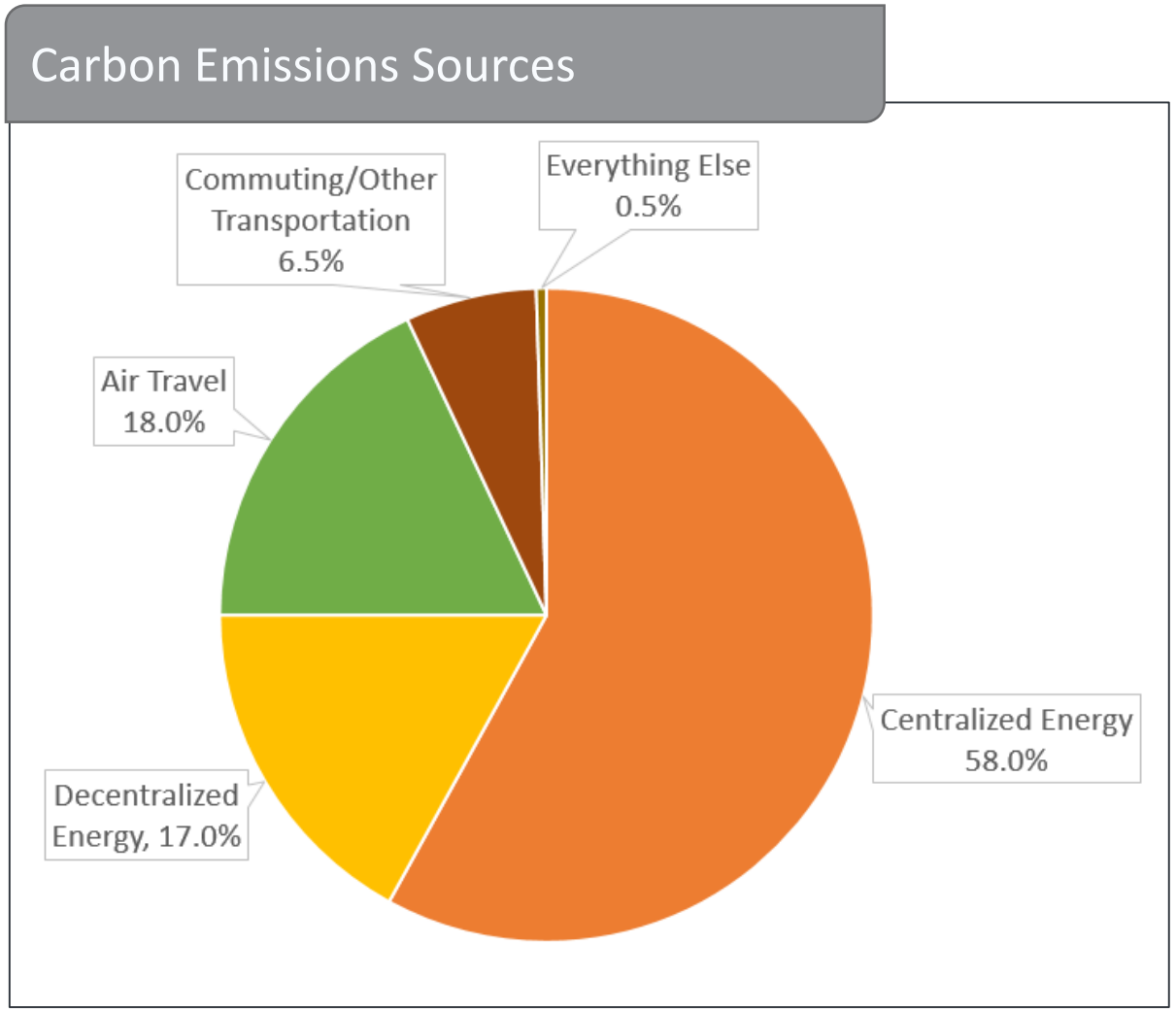
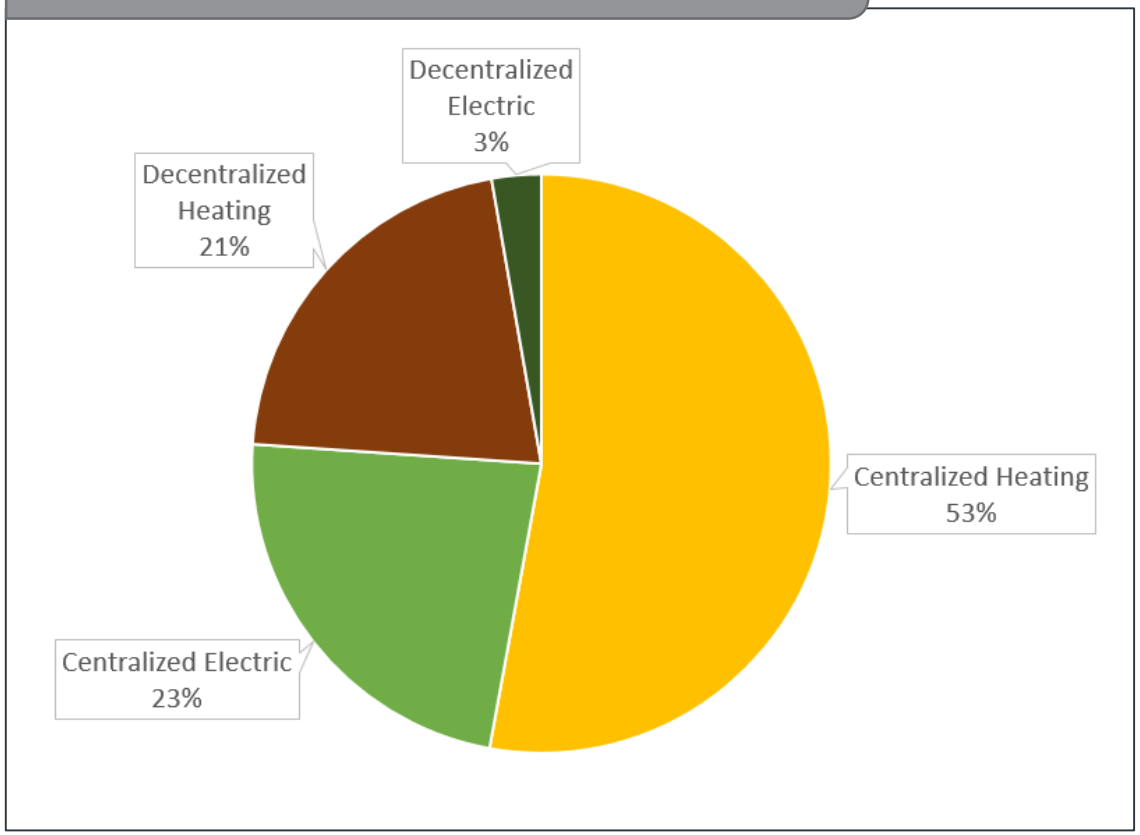
Where Does Our Carbon Come From

- Our total Carbon Footprint is 27,877 MTCDE
- By far, the largest source of Carbon Emissions on Campus comes from Energy
- Energy accounts for 75% of our Carbon Emissions
- Energy includes electricity, heating, and cooling
- There are two major categories of Energy use on campus: centralized and decentralized



How Do We Use Energy on Campus

Energy Related Emissions by Use*

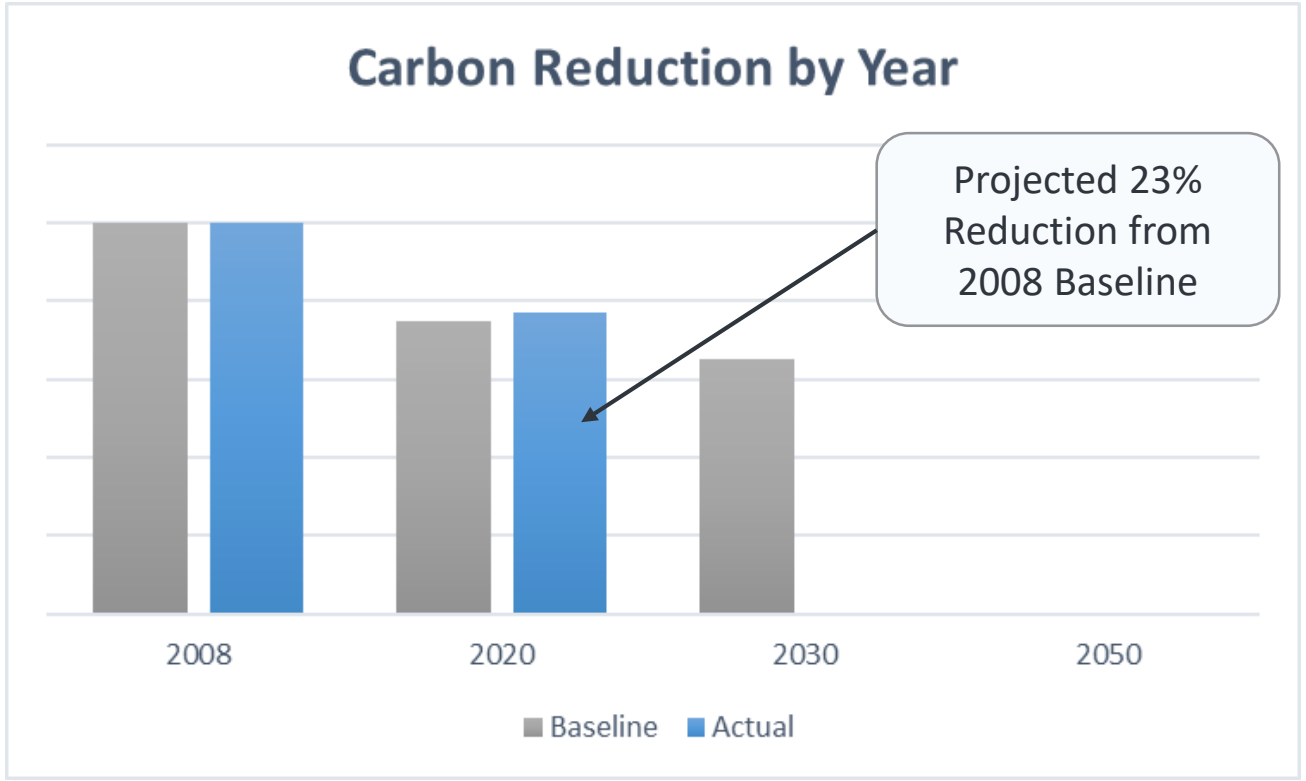


**Remember, this represents 75% of our total emissions*

- **Energy accounts for 75% of our Carbon Emissions**
- Electricity (20%):
  - Purchase Electricity from the local utility
  - Generate Electricity on campus (solar and cogen)
  - Cooling (electricity to run air conditioners (chillers))
- Heating (55%):
  - Burn natural gas to generate heat
  - Burn bio-diesel to generate heat

Carbon Reduction Goals

- Our Commitment is to be Carbon Neutral by 2050
- 25% Reduction by 2020 (relative to 2008 baseline)
- 35% Reduction by 2030 (relative to 2008 baseline)



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How Do We Reduce our Energy Carbon Emissions

Conservation

- Comprehensive Energy Projects
- Building Projects
- Deep Energy Retrofits
- Community Education

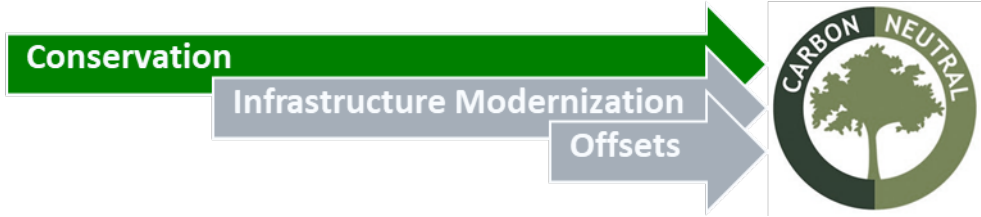
Infrastructure Modernization

- Steam to Hot Water Conversion
- Ground Source (Geothermal) Heat Pumps
- Renewable Energy Installation (Solar PV with Storage)

Offsets

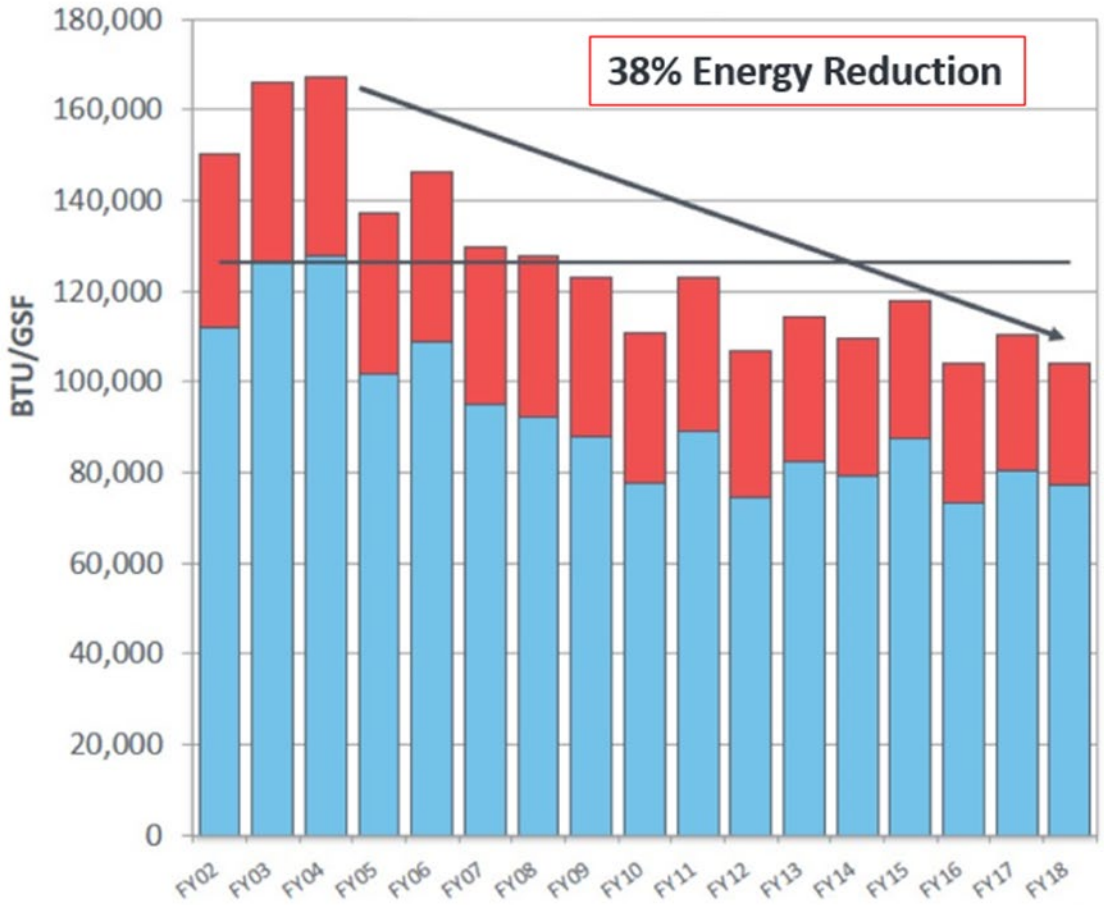
- Renewable Energy Credits
- Carbon Offsets

Conservation



- Comprehensive Energy Projects are Wesleyan's main source of energy conservation and reduction on campus
- Twelve phases of comprehensive energy reductions projects performed
- Offset $2.4M in energy costs annually
  - 10,000 MWh of electricity annually
  - 77,500 therms of natural gas annually
- Reduced our carbon emissions by 7,471 MTCDE annually

Reduction Since 2004



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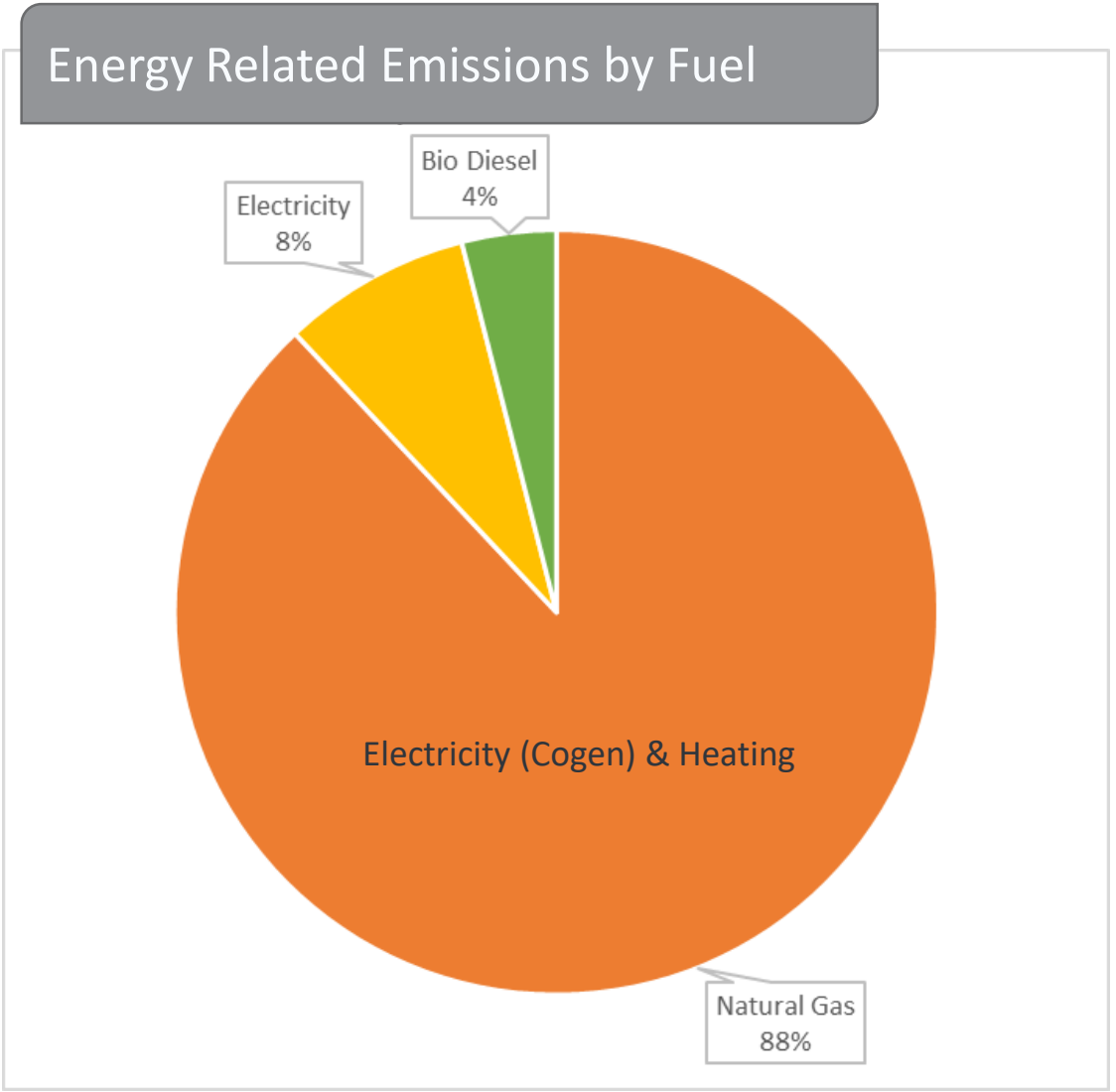
How to Make our Energy Use Carbon Neutral

- To be carbon neutral, we need to stop burning fossil fuels.
- Electricity can be generated from renewable sources (or RECs can be purchased)
- It is essential to heat our buildings without burning fossil fuels (we can do that by using electricity)



Centralized Energy

Step 1

Steam to Hot Water Conversion

- Replacement of aging infrastructure
- Significant efficiency increases
- Flexibility for future renewables
- Foundation of all future work

Step 2

Ground Source Heat Pumps (Geothermal)

- Electrification of campus (space heating & domestic hot water)
- Eliminates burning of fuel for heat
- Allows energy sharing between buildings

Step 3

Solar PV w/ Storage

- Renewable energy for electricity, heating, and cooling
- Opportunity for offsite solar projects

The Case for Hot Water Conversion

Replacement of aging infrastructure

- Over 10,000 feet of steam pipe on campus
- Some steam pipe is over 100 years old
- Boilers at the Power Plant are nearly 50 years old

Significantly more efficient

- It's more efficient to generate hot water than steam
- It's more efficient to distribute hot water than steam

Increased utilization of existing cogen assets

- Currently "throw away" nearly 50% of the thermal energy produced from cogens
- Cogens would meet 100% of our summer heat load

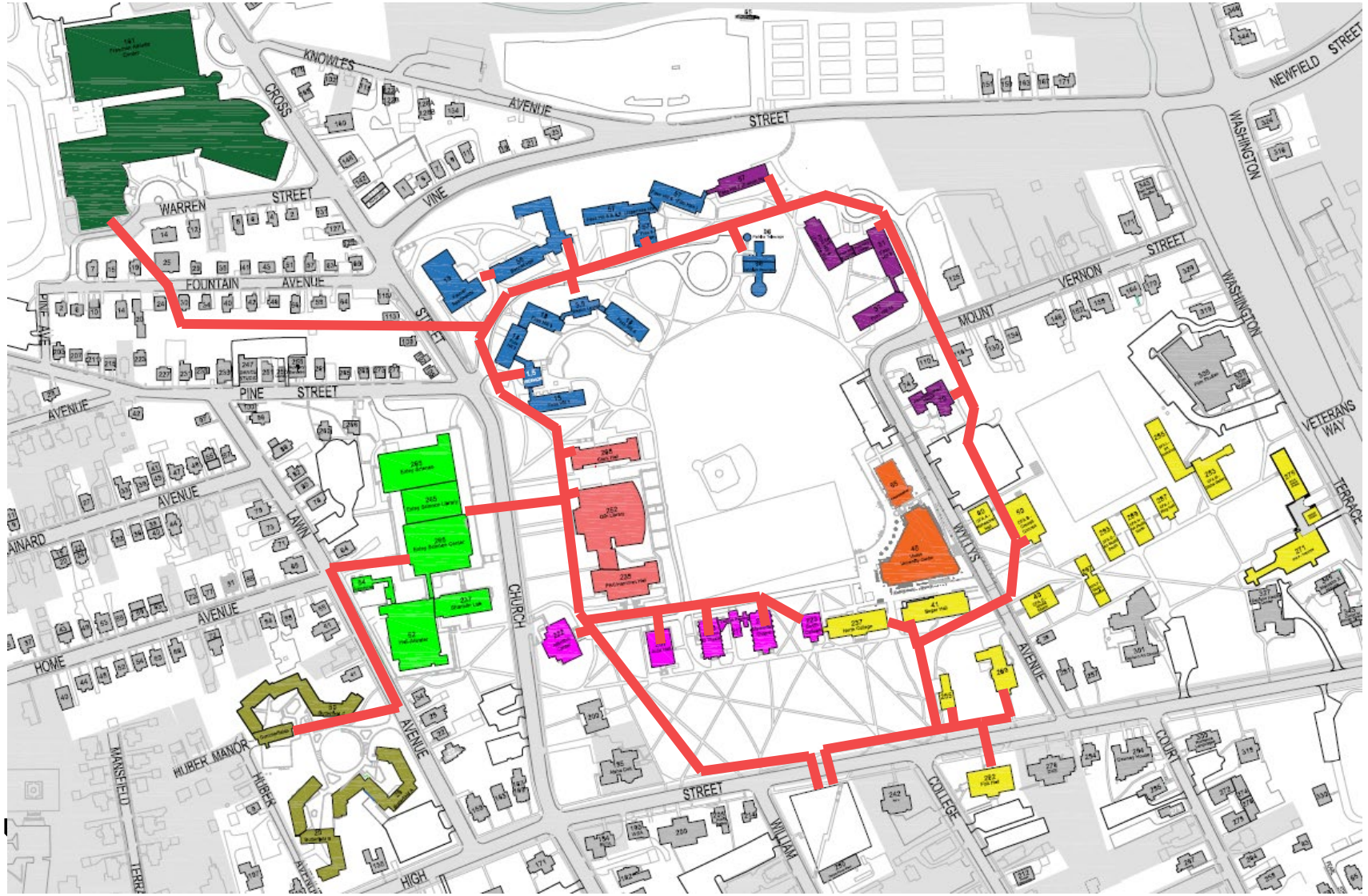
Integration of future renewables

- Nearly all renewable thermal technologies produce low temp hot water (not steam)
- Opens possibilities of heat pumps, solar thermal, fuel cells, and future renewable technologies

Hot Water Loop

Conservation
Infrastructure Modernization
Offsets

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → **Solar PV w/ Storage**



- Eight phases to convert existing steam loop to hot water New hot water distribution pipe (underground, in tunnels, and mechanical rooms) around campus
- Loop design provides flexibility and redundancy
- Combination of new and reuse of existing equipment in all mechanical rooms

Ground Source Heat Pumps

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → Solar PV w/ Storage

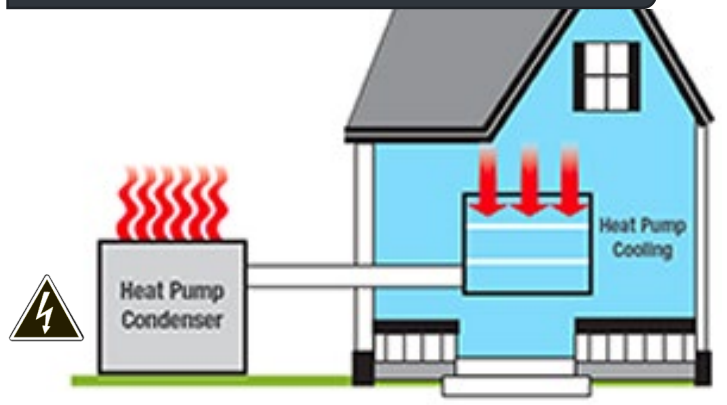
What is a Heat Pump

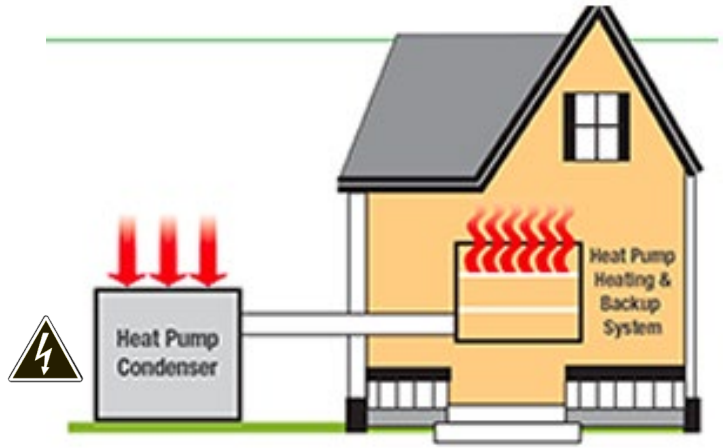
- Heat Pumps Move Heat
- Boilers and Furnaces Generate Heat (by combustion)
- It's much more efficient to move heat than to generate it
- Using a heat pump, we can move heat out of our buildings to cool them, or move heat into our buildings to heat them
- Heat pumps use electricity to move heat

What is Geothermal

- Geothermal (or ground source) refers to the heat source
- It's just a location we use to store or take heat from
- The ground acts like a giant location to store heat that we can remove or add to as needed

How Does it Work?





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Benefits of Heat Pumps

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → Solar PV w/ Storage

Converting to Heat Pumps

- Install ground source heat pumps in phases throughout campus.
- As more ground source heat pumps are installed, our electric load will increase, but our natural gas usage will decrease.
- As we continue to add ground source heat pumps, eventually we will be able to retire our boilers and cogens and stop burning natural gas on campus

Eliminates burning of fuel for heat

- Ground source heat pumps are 5 times more efficient than using combustion for heat and hot water
- Electricity is significantly easier to produce using renewable energy than thermal energy for heating and hot water

Increased Cogen Utilization

- Allows us to more efficiently use our existing cogeneration assets during the transition period

Other Benefits

- Allows energy sharing between simultaneous heating and cooling loads

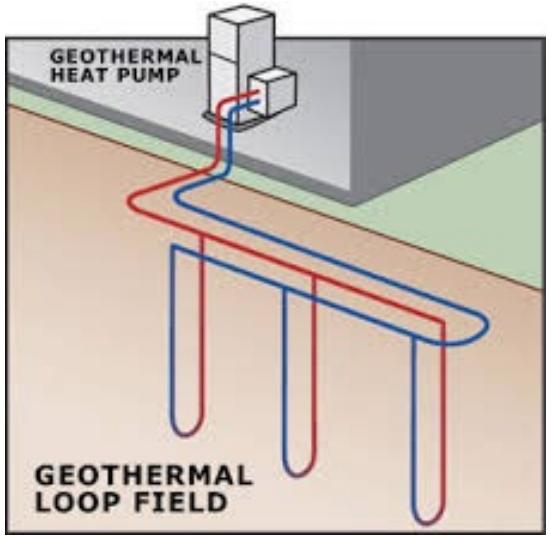
Geothermal

Conservation
Infrastructure Modernization
Offsets

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → Solar PV w/ Storage

How Much Geothermal Do We Need?

- On average, our campus heating and domestic hot water load is ~4,200 tonnes (50 MMBTU/hr)
- All else being equal, it would take ~24 acres of well field to meet our heating load (250 ft^2 land area per ton)
- That's roughly the equivalent of 4 Andrus Fields, 18 NFL Football Fields, or about 6.5% of our campus footprint



Solar

Renewable energy for electricity, heating, and cooling

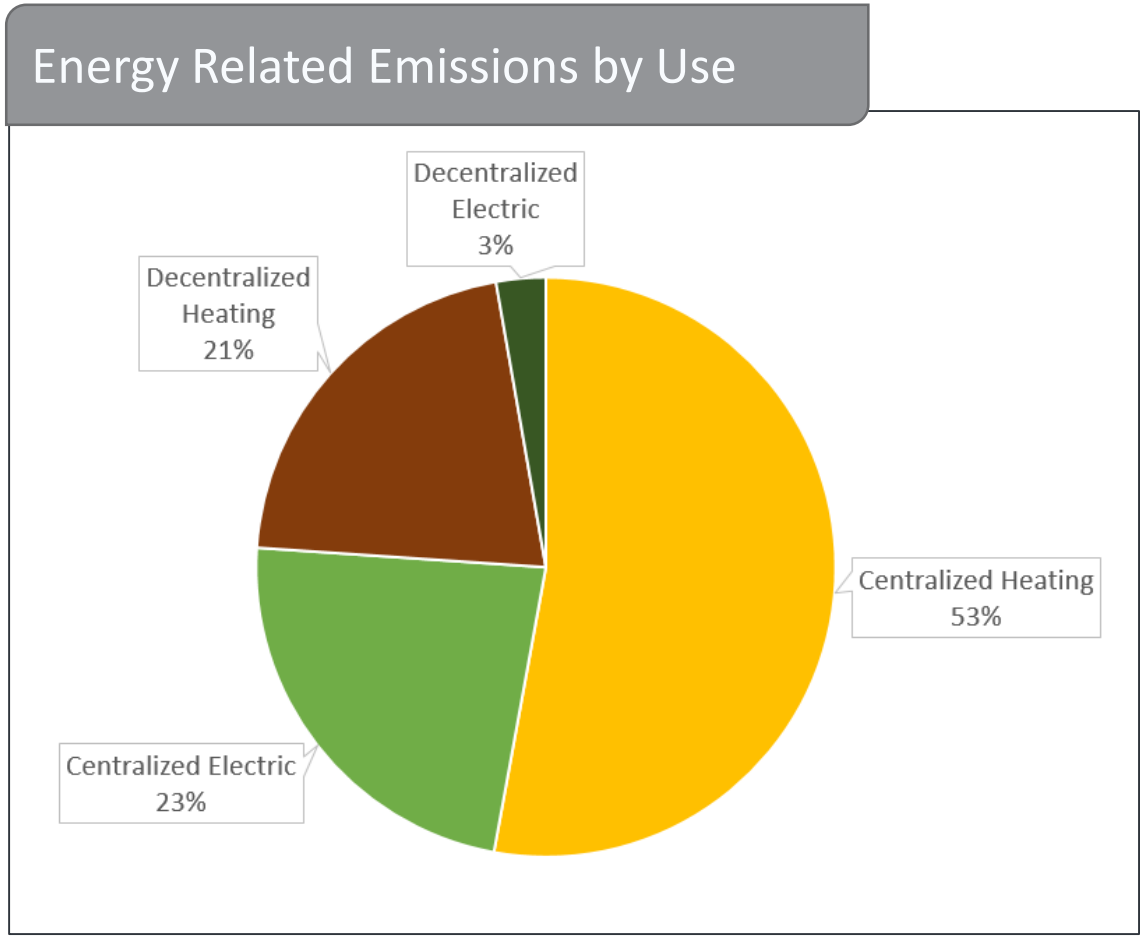
- On site PV installation will provide a portion of our electricity, purchased electricity will provide the balance
- Grid purchased electricity is increasingly green and this trend will continue
- Battery storage will allow redundancy in case of a utility outage
- Storage will allow capacity payment reductions

How Much PV Would We Need?

- On average, it would take about 16 solar arrays the size of the one at Long Lane to meet our campus electric load today.
- All else being equal, it would take another 5 solar arrays to heat our campus with heat pumps (that's 21 total to meet our electric + heating needs).
- That would mean covering about 25% of our campus with solar panels (~85 acres)

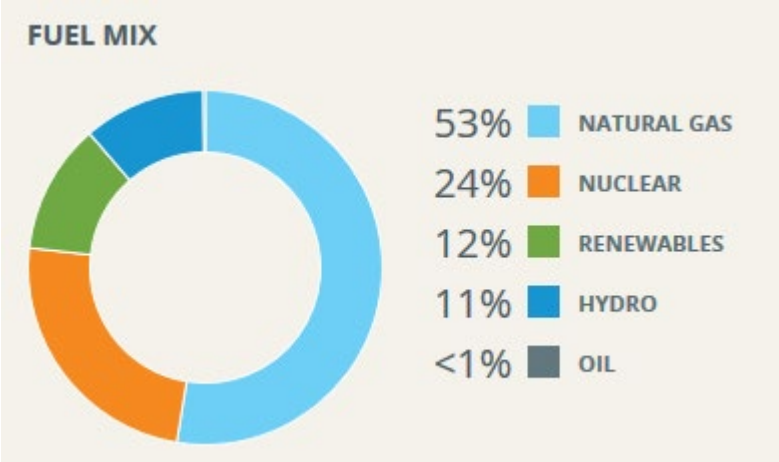
Decentralized Energy

- Many of our buildings are not on the central steam or electric loops, but represent only a portion of our energy use:
  - ~24% of our energy usage (mainly wood frame houses, small institutional buildings, and rental properties)
- There are several options for these properties:
  - Connection to the new hot water loop and microgrid
  - Conversion to stand-alone heat pumps / electric heating and purchase RECs
  - Divestment
  - Purchasing carbon offsets



Offsets

- Our electricity demand will increase as we heat our campus with heat pumps, meaning our purchased electricity will increase
  - The grid itself will continue to become greener
  - The amount of Renewable Energy Certificates (RECs) purchased will increase
- Burning fuels will still have a minor role in our energy needs on campus:
  - On very cold days, burning of fuel will be needed to supplement heat pumps for heating
  - Emergency and life safety generators will still burn fuels
  - This carbon footprint can be eliminated by buying carbon offsets



Questions?

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